

Arterial Hemodynamics in the horse: insights from a 1D arterial network model

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Introduction

Deeper insight into intra-arterial pressure and flow may increase the understanding of aortic rupture in horses, the relatively high incidence of sudden death due to arterial rupture and development of aortic insufficiency in older animals. A better understanding of these diseases is needed to improve rider's safety and animal welfare. The aim of this study is to gain insight into equine arterial hemodynamics and physiology through 1D arterial network simulations.

Materials and Methods

Anatomical data (lengths, diameters, branching angles) from the equine aorta and its most significant branches towards the head, abdominal organs and the front and hind legs were collected post-mortem from five horses that had been euthanized for reasons not related to the cardiovascular system. In total, data on 113 arterial segments was obtained, and segments were connected to form the input for a previously validated (in humans) 1D arterial network model. Data on terminal resistance and arterial compliance parameters were tuned to equine physiology. Given the large arterial diameters, Womersley correction was used upon computation of friction coefficients, and the input into the arterial system was provided via a scaled time-varying elastance model of the left heart. The heart rate was set to 40 bpm, a normal physiological value for the horse at rest.

Results and Discussion

Figure 1 displays pressure (in mmHg) and flow velocity (in m/s) at the level of ascending (AAO) and descending aorta (DAO), right common carotid (CA), external iliac (IL) and median (MED) arteries, sites commonly used for ultrasound examination. Aortic systolic/diastolic pressure was 136/81 mmHg with a pulse pressure of 55 mmHg. Cardiac output was 33 L/min, with an ejection fraction of 57 % and a stroke volume of 816 ml. Maximum value of the Womersley number was 35.5. Aortic PWV calculated with the transit time method, from the proximal ascending aorta to the distal abdominal aorta, was 5.86 m/s. Of note is the significant amplification in pressure from the heart to the periphery, and a much more oscillatory nature of pressure and flow waveforms compared to humans. Velocity waveforms are, however, in line with observations from Doppler ultrasound measurements.

Conclusions

This work resulted in a unique anatomical dataset on the equine arterial tree. Initial model simulations indicate quite a large disparity of intra-arterial waveforms compared to extrapolations from human physiology, probably because the large diameters and long vessels (and associated inertial effects) lead to more complex hemodynamics. The model will be validated with invasive high-fidelity catheter measurements and ultrasound measurements.

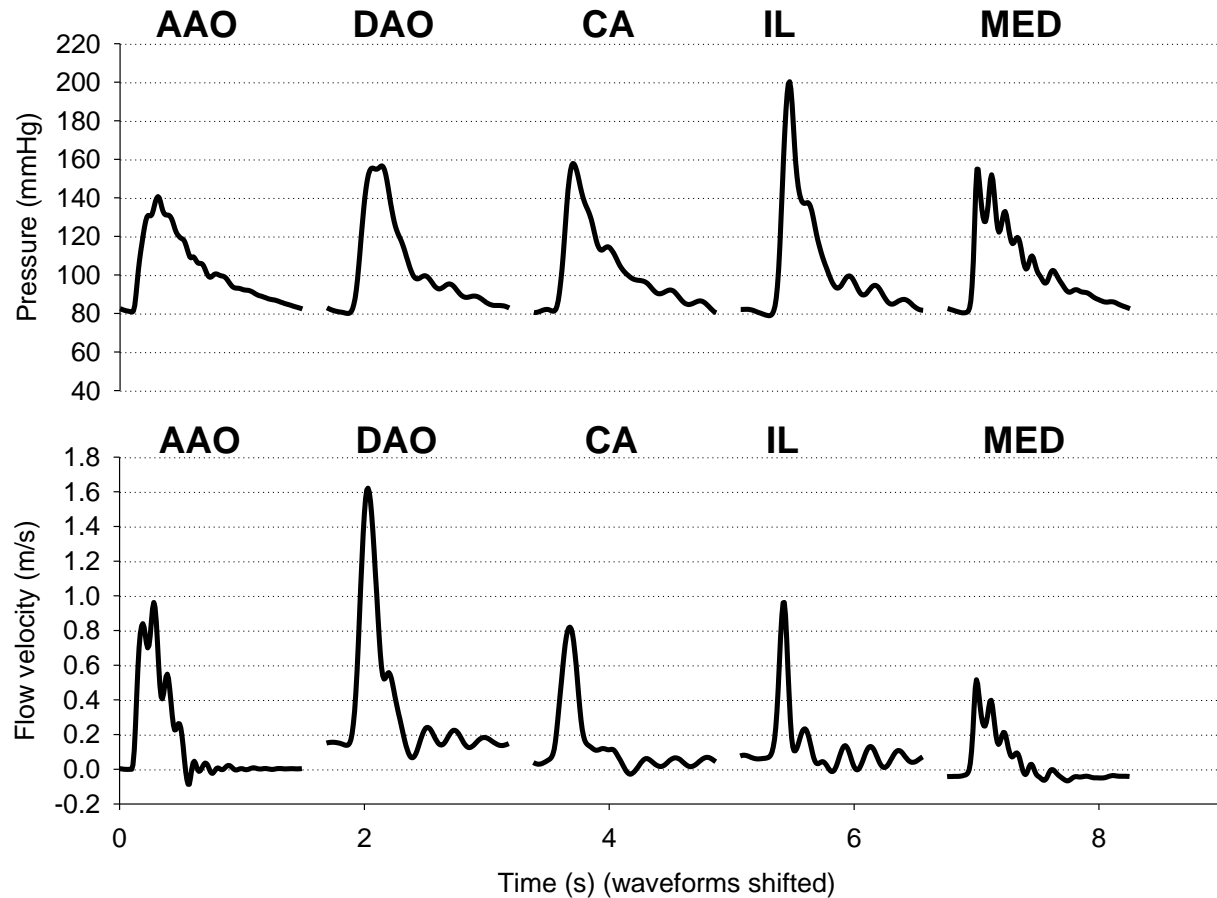


Figure 1. Pressure and flow velocity at different locations of the equine arterial tree.

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References

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